What is claimed is:

1. A method for automatically controlling the output of a continuous process with a liquid carrier that contains one or more gases, the method comprising the steps of:

a.) setting a quantitative target for volume-% of one or more gases in the liquid carrier;

b.) calculating the volume percentage of said gas in said liquid sample by using equation (28)

$$x\% = \frac{V_s}{V_s + V} \quad (28)$$

wherein V is the volume of the gas-free liquid calculated by equation (23)

$$V = \frac{1}{\rho_1} - \left[\frac{P_2}{P_2 - P_1} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT}{P_2 - P_1} g(\frac{\Delta P}{Q^a}) \right] \quad (23)$$

in which P_1 and P_2 are two different ambient pressures and $\Delta P = P_2 - P_1$, ρ_1 and ρ_2 are apparent densities of the liquid sample measured at P_1 and P_2, respectively, R is the constant of the Ideal Gas Law, T is the liquid temperature, Q is the flow rate, and $g(\Delta P/Q^a)$ is a function through which the gas solubility coefficients at a dynamic state are determined ; and V_s is determined by equation (27)

$$V_s = \frac{T_s}{T} \frac{P_1 P_2}{P_s (P_2 - P_1)} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT_s}{P_s} \left(\frac{P_1}{P_2 - P_1} g(\frac{\Delta P}{Q^a}) - g\left(\frac{P_1 - P_s}{Q^a} \right) \right) \quad (27)$$

in which P_s and T_s are standard pressure (1 atm) and temperature (0°C), P_1, P_2, P_s, ΔP, ρ_1, ρ_2, R, Q, and T are the same as defined in this claim, and $g\left(\frac{P_1 - P_s}{Q^a} \right)$ is a function for determining the amount of gas being dissolved between P_1 and P_s;

c.) comparing the calculated volume-% gas to the target volume-% gas; and,

d.) if the calculated volume-% gas in the liquid carrier is greater or less than the target volume-% gas, lowering or raising the amount of gas in the liquid carrier.

2.   A method for controlling the output of processing a liquid–gas mixture in a batch mode, the method comprising the steps of:

a.) setting a quantitative target for volume-% of one or more gases in the mixture;

c.) subjecting the mixture to two different pressure states and measuring the apparent density of the mixture at each of the two pressure states;

d.) calculating the volume percentage of said gas in said liquid sample by using equation (28)

$$x\% = \frac{V_s}{V_s + V} \quad (28)$$

wherein V_s is determined by equation (33)

$$V_s = \frac{T_s}{T} \frac{P_1 P_2}{P_s (P_2 - P_1)} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT_s}{C} \quad [33]$$

in which P_1 and P_2 are two different ambient pressures, ρ_1 and ρ_2 are apparent densities of the liquid sample measured at P_1 and P_2, respectively, P_s and T_s are standard pressure (1 atm) and temperature (0°C), R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, and C is the gas solubility coefficient at a static state; and V is the volume of the gas-free liquid calculated through equation (32)

$$V = \frac{1}{\rho_1} - \left[\frac{P_2}{P_2 - P_1} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT}{C} \right] \quad [32]$$

in which T is the liquid temperature, and P_1, P_2, ρ_1, ρ_2, and R are the same as defined in this claim,

e.) comparing the calculated volume-% gas to the target volume-% gas; and,

f.) if the calculated volume-% gas in the liquid carrier component is greater or less than the target volume-% gas, lowering or raising the amount of gas mixed in the liquid.

3.   A method for automatically controlling the output of a continuous process that requires mixing of a solid or liquid component with a liquid carrier component, the method comprising the steps of:

a.) setting a quantitative target for weight-% in the liquid carrier component of one or more solids and/or for concentration of one or more liquids in the liquid carrier component;

b.) continuously mixing said solids and/or liquids with the liquid carrier component;

c.) determining the true density, ρ, by employing equation (24)

$$\rho = \frac{1}{V} \quad (24)$$

wherein the volume, V, is calculated from equation (23)

$$V = \frac{1}{\rho_1} - \left[\frac{P_2}{P_2 - P_1} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT}{P_2 - P_1} g(\frac{\Delta P}{Q^a}) \right] \quad (23)$$

in which P_1 and P_2 are two different ambient pressures and $\Delta P = P_2 - P_1$, ρ_1 and ρ_2 are apparent densities of the liquid sample measured at P_1 and P_2, respectively, R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, Q is the flow rate, and $g(\Delta P/Q^a)$ is a function through which the gas solubility coefficients at a dynamic state are determined;

d.) calculating the weight-% of solids and/or the liquid concentration in the mixture from the true density ρ so determined;

e.) comparing the calculated weight-% solids or concentration to the target weight-% solids or concentration; and,

f.) if the calculated weight-% solids or concentration is greater or less than the target weight-% solids or concentration, lowering or raising the amount of solids or liquids mixed in step b.).

4.   The method of claim 3 for continuously coating a substrate, which method comprises:

a.) setting a quantitative target for weight-% of one or more solids to be coated onto a substrate;

b.) continuously applying the solids to the substrate via a carrier fluid;

c.) measuring the apparent density of the slurry;

d.) determining the true density of the slurry;

e.) calculating the weight-% of solids in the slurry in the manner recited in claim 3;

f.) comparing the calculated weight-% solids to the target weight-% solids; and,

g.) if the calculated weight-% is greater or less than the target weight-%, lowering or raising the amount of solids applied in step b.).

5. The method of claim 4, in which the substrate is a paper web and the solids component comprises kaolin clay, calcium carbonate, titanium dioxide, or alumina trihydrate.

6. The method of claim 3 for controlling the output of a continuous process for preparing a syrup, which method comprises:

a.) setting a quantitative target for a concentration of one or more carbohydrates and/or carbohydrate-containing liquids to be blended into a syrup;

b.) continuously supplying the carbohydrate and/or carbohydrate-containing liquid and a dilution liquid to a vessel and mixing said liquids to form a slurry;

c.) measuring the apparent density of the slurry;

d.) determining the true density of the slurry;

e.) converting this true density to the calculated carbohydrate concentration;

f.) comparing the calculated carbohydrate concentration to the target carbohydrate concentration; and,

g.) if the calculated carbohydrate concentration is greater or less than the target carbohydrate concentration, lowering or raising the amount of carbohydrates and/or volume of carbohydrate-containing liquids supplied in step b.).

7.   The method of claim 4, in which carbohydrates comprising sucrose and carbohydrate-containing liquids comprising corn syrup and high fructose corn syrup are mixed with a dilution liquid comprising water.

8.   An indirect method of determining the amount of gas entrained in a liquid in a batch mode, the method comprising the steps of:

subjecting a mixture of an incompressible liquid sample and a compressible gas to two different pressure states,

measuring the temperature and apparent density of the mixture at each of the two pressure states, and

calculating the volume percentage of said gas in said liquid sample by using equation (28)

$$x\% = \frac{V_s}{V_s + V} \qquad (28)$$

wherein V_s is determined by equation (33)

$$V_s = \frac{T_s}{T} \frac{P_1 P_2}{P_s (P_2 - P_1)} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT_s}{C} \qquad [33]$$

in which P_1 and P_2 are two different ambient pressures, ρ_1 and ρ_2 are apparent densities of the liquid sample measured at P_1 and P_2, respectively, P_s and T_s are standard pressure (1 atm) and temperature (0°C), R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, and C is the gas solubility coefficient at a static state; and V is the volume of the gas-free liquid calculated through equation (32)

$$V = \frac{1}{\rho_1} - \left[\frac{P_2}{P_2 - P_1}\left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right) - \frac{RT}{C} \right]$$ [32].

9. An indirect method of continuously determining the amount of gas entrained in a liquid, the method comprising the steps of:

continuously measuring the temperature, flow rate, and apparent density of the mixture at two different pressure states, and

calculating the volume percentage of said gas in said liquid by using equation (28)

$$x\% = \frac{V_s}{V_s + V}$$ (28)

wherein V is the volume of the gas-free liquid calculated by equation (23)

$$V = \frac{1}{\rho_1} - \left[\frac{P_2}{P_2 - P_1}\left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right) - \frac{RT}{P_2 - P_1}g(\frac{\Delta P}{Q^a}) \right]$$ (23)

in which P_1 and P_2 are two different ambient pressures and $\Delta P = P_2 - P_1$, ρ_1 and ρ_2 are apparent densities of the liquid sample measured at P_1 and P_2, respectively, R is the constant of the Ideal Gas Law, T is the liquid temperature, Q is the flow rate, $g(\Delta P/Q^a)$ is a function for determining the amount of gas being dissolved between P_2 and P_1, and V_s is determined by equation (27)

$$V_s = \frac{T_s}{T}\frac{P_1 P_2}{P_s(P_2 - P_1)}\left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right) - \frac{RT_s}{P_s}\left(\frac{P_1}{P_2 - P_1}g(\frac{\Delta P}{Q^a}) - g\left(\frac{P_1 - P_s}{Q^a}\right)\right)$$ (27)

in which P_s and T_s are standard pressure (1 atm) and temperature (0°C), and $g\left(\frac{P_1 - P_s}{Q^a}\right)$ is a function for determining the amount of gas being dissolved between P_1 and P_s.

10. An indirect method of determining the air-free density of a liquid at a static state, the method comprising the steps of:

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subjecting a mixture of an incompressible liquid sample and a compressible gas to two different pressure states,

measuring the temperature and apparent density of the mixture at each of the two pressure states, and

calculating the true density of said liquid sample by using equation (24)

$$\rho = \frac{1}{V} \qquad (24)$$

wherein V is the volume of the gas-free liquid as determined by equation (32)

$$V = \frac{1}{\rho_1} - \left[\frac{P_2}{P_2 - P_1} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT}{C} \right] \qquad [32]$$

in which P_1 and P_2 are two different ambient pressures, ρ_1 and ρ_2 are apparent densities of the liquid sample measured at P_1 and P_2, respectively, R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, and C is the gas solubility coefficient at a static state.

11.   An indirect method of determining the gas-free density of a gas-liquid mixture at a dynamic state, the method comprising the steps of:

measuring two different apparent densities of the mixture and two corresponding ambient pressures at which the apparent densities are determined,

measuring the temperature and flow rate, and

calculating the true density of said liquid sample by using equation (24)

$$\rho = \frac{1}{V} \qquad (24)$$

wherein V is the volume of the gas-free liquid as determined by equation (23)

$$V = \frac{1}{\rho_1} - \left[\frac{P_2}{P_2 - P_1} \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right) - \frac{RT}{P_2 - P_1} g \left(\frac{\Delta P}{Q^a} \right) \right] \qquad [23]$$

in which P_1 and P_2 are two different ambient pressures and $\Delta P = P_2 - P_1$, ρ_1 and ρ_2 are apparent densities of the liquid sample measured at P_1 and P_2, respectively, R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, and $g\left(\dfrac{\Delta P}{Q^a}\right)$ is the gas solubility function.

12. An indirect method for determining gas solubility coefficients for a gas-liquid mixture at a dynamic state, the method comprising the steps of:

a.) subjecting the said gas-liquid mixture to flow at several different flow rates, $Q_1, Q_2, \cdots, Q_i$;

b.) measuring two different apparent densities of the mixture and two related ambient pressures at which the apparent densities are determined at each of the flow rates;

c.) acquiring off-line the true, gas-free liquid density, ρ^*, through one-time measurement;

d.) determining the gas solubility coefficients, $A_0, A_1, A_2, \cdots, A_i$, by solving a group of linear equations (19)

$$A_0 + A_1\left(\frac{\Delta P}{Q^a}\right) + A_2\left(\frac{\Delta P}{Q^a}\right)^2 + \cdots + A_i\left(\frac{\Delta P}{Q^a}\right)^i = S_1 \bigg|_{Q=Q_1}$$

$$A_0 + A_1\left(\frac{\Delta P}{Q^a}\right) + A_2\left(\frac{\Delta P}{Q^a}\right)^2 + \cdots + A_i\left(\frac{\Delta P}{Q^a}\right)^i = S_2 \bigg|_{Q=Q_2} \qquad (19)$$

$$\cdots\cdots$$

$$A_0 + A_1\left(\frac{\Delta P}{Q^a}\right) + A_2\left(\frac{\Delta P}{Q^a}\right)^2 + \cdots + A_i\left(\frac{\Delta P}{Q^a}\right)^i = S_i \bigg|_{Q=Q_i}$$

in which $Q_1, Q_2, \cdots, Q_i$ are the different flow rates generated for obtaining the gas solubility coefficients at a dynamic state, ΔP is the difference of the said two ambient pressures at each of the flow rates, a is an index reflecting the

weak influence of flow rate on gas solubility, and $S_1, S_2, \cdots, S_i$ are intermediate variables determined by equation (20)

$$S_1 = \frac{1}{RT}\left[P_I\left(\frac{1}{\rho_I} - \frac{1}{\rho^*}\right) - P_{II}\left(\frac{1}{\rho_{II}} - \frac{1}{\rho^*}\right)\right]\Bigg|_{Q=Q_1}$$

$$S_2 = \frac{1}{RT}\left[P_I\left(\frac{1}{\rho_I} - \frac{1}{\rho^*}\right) - P_{II}\left(\frac{1}{\rho_{II}} - \frac{1}{\rho^*}\right)\right]\Bigg|_{Q=Q_2} \qquad (20)$$

$$\cdots\cdots$$

$$S_i = \frac{1}{RT}\left[P_I\left(\frac{1}{\rho_I} - \frac{1}{\rho^*}\right) - P_{II}\left(\frac{1}{\rho_{II}} - \frac{1}{\rho^*}\right)\right]\Bigg|_{Q=Q_i}$$

in which P_I and P_{II} are two different ambient pressures measured at each of the flow rates, ρ_I and ρ_{II} are apparent densities of the gas-liquid mixture measured at P_I and P_{II}, respectively, R is the constant of the Ideal Gas Law, T is the liquid temperature, Q is the flow rate, and ρ^* is the predetermined gas-free liquid density as defined in c.);

e.) attaining the gas solubility function

$$g\left(\frac{\Delta P}{Q^a}\right) = A_0 + A_1\left(\frac{\Delta P}{Q^a}\right) + A_2\left(\frac{\Delta P}{Q^a}\right)^2 + \cdots + A_i\left(\frac{\Delta P}{Q^a}\right)^i$$ upon the solution of the gas

solubility coefficients, $A_0, A_1, A_2, \cdots, A_i$.

13. An indirect method for determining the gas solubility coefficient for a gas-liquid mixture at a static state, the method comprising the steps of:

a.) measuring two different apparent densities of the mixture and two related ambient pressures at which the apparent densities are determined;

b.) acquiring off-line the true, gas-free liquid density, ρ^*, through one-time measurement;

c.) determining the gas solubility coefficients, C, at a static state by solving equation (30)

$$C = RT(P_{II} - P_I)\left[P_I\left(\frac{1}{\rho_I} - \frac{1}{\rho^*}\right) - P_{II}\left(\frac{1}{\rho_{II}} - \frac{1}{\rho^*}\right)\right]^{-1} \qquad (30)$$

in which P_I and P_{II} are two different ambient pressures, ρ_I and ρ_{II} are apparent densities of the gas-liquid mixture measured at P_I and P_{II}, respectively, R is the constant of the Ideal Gas Law, T is the liquid temperature, and ρ^* is the predetermined gas-free liquid density as defined in b.).

14. The method of one of claims 8-13, wherein said two pressure states differ from one another by at least 1 psi, preferably by at least 1 atmosphere.

15. The method of one of claims 8-13, wherein said two pressure states differ from one another at least to the extent that the two different apparent densities of said liquid differ from one another by at least 0.2%, preferably by at least 0.5%.

16. A direct method of determining the amount of gas entrained in a liquid, the method comprising the steps of:

subjecting a mixture of an incompressible liquid sample and a compressible gas to two different pressure states,

measuring the temperature and volume of the mixture at each of the two pressure states,

determining the changes in volume of the mixture between the two pressure states, and

calculating the volume percentage of said gas in said liquid sample by using equation (28)

$$x\% = \frac{V_s}{V_s + V} \qquad (28)$$

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wherein V_s is determined by equation (37)

$$V_s = \frac{T_s}{T} \frac{P_1 P_2 \Delta V}{P_s (P_2 - P_1)} - \frac{RT_s}{C}$$ [37]

in which T_s is 0°C, P_1 and P_2 are two different ambient pressures, ΔV is the volume difference of the gas-liquid mixture in a sample chamber between P_1 and P_2, R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, P_s is 1 atm, and C is the gas solubility coefficient at a static state; and V is the volume of the gas-free liquid in the sample chamber determined by equation (36)

$$V = V_{t1} - \left[\frac{P_2 \Delta V}{P_2 - P_1} - \frac{RT}{C} \right]$$ (36)

in which V_{t1} is the volume of the gas-liquid mixture in the sample chamber at P_1.

17.   A direct method of determining the air-free density of a liquid, the method comprising the steps of:

subjecting a mixture of an incompressible liquid sample and a compressible gas to two different pressure states,

measuring the temperature and volume of the mixture at each of the two pressure states,

determining the changes in volume of the mixture between the two pressure states, and

calculating the true density of said liquid sample by using equation (24)

$$\rho = \frac{1}{V}$$ (24)

wherein V is the volume of the gas-free liquid as determined by equation (36)

$$V = V_{t1} - \left[\frac{P_2 \Delta V}{P_2 - P_1} - \frac{RT}{C} \right]$$ [36]

in which P₁ and P₂ are two different ambient pressures, V_{l1} is the volume of gas-liquid mixture in the sample chamber at P₁. ΔV is the change in volume of gas-liquid mixture in the sample chamber between P₁ and P₂, R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, and C is the gas solubility coefficient at a static state.

18.   A direct method for determining the gas solubility coefficient for a gas-liquid mixture at a static state, the method comprising the steps of:

a.) subjecting a mixture of an incompressible liquid sample and a compressible gas to a sample chamber;

b.) compressing or expanding the sample chamber and measuring the volume of gas-liquid mixture, V_{ll}, at the first pressure state, P_I;

c.) compressing or expanding the sample chamber further and measuring the volume of gas-liquid mixture, V_{lll}, at the second pressure state, P_{ll};

d.) increasing the pressure of the sample chamber excessively to dissolve all of the free gas and measuring the volume of gas-free liquid in the sample chamber, V;

e.) calculating the volumes of the free gas, V_I and V_{ll}, at P_I and P_{ll}, respectively, $V_I = V_{ll} - V$ and $V_{ll} = V_{lll} - V$;

f.) determining the gas solubility coefficient, C, by using equation (34)

$$C = \frac{RT(P_{ll} - P_I)}{P_I V_I - P_{ll} V_{ll}} \qquad (34)$$

in which P₁ and P₁₁ are two different ambient pressures, V₁ and V₁₁ are volumes of the gas-liquid mixture in the sample chamber measured at P₁ and P₁₁, respectively, R is the constant of the Ideal Gas Law, T is the liquid temperature.

19. The method of claim 18, in which the volume of gas-free liquid in the sample chamber, V, is determined with degassing chemicals or by allowing the sample to sit for a sufficiently long time to dissipate all of the free gas bubbles, rather than by the procedure of step d.).

20. The method of one of claims 16-19, wherein said two pressure states differ from one another at least to the extent that the two different volumes differ from one another by at least 0.2%, preferably by at least 0.5%.

21. The method of one of claims 16-19, wherein said two pressure states differ from one another by at least 1 psi, preferably by at least 1 atmosphere.

22. A method for controlling the output of a process with a liquid carrier that contains one or more gases, the method comprising the steps of:

a.) setting a quantitative target for volume-% of one or more gases in the liquid carrier;

b.) calculating the volume percentage of said gas in said liquid sample by using equation (28)

$$x\% = \frac{V_s}{V_s + V} \quad (28)$$

wherein V_s is determined by equation (37)

$$V_s = \frac{T_s}{T} \frac{P_1 P_2 \Delta V}{P_s(P_2 - P_1)} - \frac{RT_s}{C} \quad [37]$$

in which T_s is 0°C, P_1 and P_2 are two different ambient pressures, ΔV is the volume difference of the free gas between P_1 and P_2, R is the constant of the Ideal Gas Law, T is the temperature of the liquid sample, P_s is 1 atm, and C is the gas solubility coefficient at a static state; and V is the volume of the gas-free liquid in the sample chamber determined by equation (36)

$$V = V_{l1} - \left[\frac{P_2 \Delta V}{P_2 - P_1} - \frac{RT}{C} \right] \qquad (36)$$

in which V_{l1} is the volume of the gas-liquid mixture in the sample chamber at P_1, and $P_1, P_2, P_s, \Delta V, R$, and C are the same as being defined in this claim;

c.) comparing the calculated volume-% gas to the target volume-% gas; and,

d.) if the calculated volume-% gas in the liquid carrier is greater or less than the target volume-% gas, lowering or raising the amount of gas in the liquid carrier.

23. A method for controlling the output of a process for preparing a carbonated beverage, which method comprises:

a.) setting a quantitative target for a concentration of carbon dioxide to be blended into an aqueous medium;

b.) supplying carbon dioxide to the aqueous medium in a vessel and mixing those components to form a carbonated aqueous medium in the vessel at a preset "bottling" pressure P_0, wherein P_0 is the produced "bottling" pressure inside a sealed carbonated beverage container, at which pressure all of the free carbon dioxide is dissolved into the aqueous medium;

c.] diverting a carbonated aqueous medium sample from the vessel into a sample measurement chamber at the same "bottling" pressure P_0;

d.) reducing the aqueous medium pressure from P_0 to P_1 allowing the dissolved carbon dioxide to start to be released back to the aqueous medium in a free-bubble form while the volume of the sample measurement chamber to be expanded correspondingly;

e.) reducing the aqueous medium pressure further from P_1 to P_2 allowing more dissolved carbon dioxide to be released back to the aqueous medium in a free-bubble form while the volume of the measurement chamber to be expanded further;

f.) measuring the change in volume of the carbon dioxide liquid mixture between P_1 and P_2;

g.) determining the volume of free carbon dioxide, V_s, in the carbonated aqueous medium at the standard condition using equation (37)

$$V_s = \frac{T_s}{T} \frac{P_1 P_2}{P_s (P_2 - P_1)} \Delta V - \frac{RT_s}{C} \qquad (37)$$

in which P₁ and P₂ are two different ambient pressures, ΔV is the change in sample volume between P₁ and P₂, P_s and T_s are standard pressure and temperature, T is the temperature of the liquid sample, C is the gas solubility coefficient at a static state, and R is the constant of the Ideal Gas Law;

h.] calculating the carbon dioxide concentration using equation (28)

$$x\% = \frac{V_s}{V_s + V} \qquad (28)$$

wherein V_s is the volume of free carbon dioxide determined in step g.) and V is the volume of carbonated aqueous medium in the sample chamber at a preset "bottling" pressure P_0 upon which no free bubble should present;

i.) comparing the calculated carbon dioxide concentration to the target carbon dioxide concentration; and,

j.) if the calculated carbon dioxide concentration is greater or less than the target carbon dioxide concentration, lowering or raising the volume of carbon dioxide supplied.

24.   A method for controlling the output of a process for preparing a carbonated beverage, which method comprises:

a.) setting a quantitative target for a concentration of carbon dioxide to be blended into an aqueous medium;

b.) supplying carbon dioxide to the aqueous medium in a vessel and mixing those components to form a carbonated aqueous medium in the vessel ;

c.] diverting a carbonated aqueous medium sample from the vessel into a sample measurement chamber at the first pressure state, P_1, with the presence of free carbon dioxide bubbles in the aqueous medium;

d.) reducing the aqueous medium pressure to the second pressure state, P_2, allowing more dissolved carbon dioxide to be released back to the aqueous medium in a free-bubble form while the volume of the measurement chamber to be expanded correspondingly;

e.) measuring the change in volume of the carbon dioxide liquid mixture between P_1 and P_2;

f.) determining the volume of free carbon dioxide, V_s, in the carbonated aqueous medium at the standard condition using equation (37)

$$V_s = \frac{T_s}{T} \frac{P_1 P_2}{P_s (P_2 - P_1)} \Delta V - \frac{RT_s}{C} \qquad (37)$$

in which P1 and P2 are two different ambient pressures, ΔV is the change in sample volume between P1 and P2, P_s and T_s are standard pressure and temperature, T is the temperature of the liquid sample, C is the gas solubility coefficient at a static state, and R is the constant of the Ideal Gas Law;

g.) determining the volume of aqueous medium, V, in which no free carbon dioxide bubble is present, by equation (36)

$$V = V_{t1} - \left[\frac{P_2 \Delta V}{P_2 - P_1} - \frac{RT}{C} \right] \qquad (36)$$

in which V_{t1} is the volume of gas-liquid mixture in the sample chamber at P1;

h.] calculating the carbon dioxide concentration using equation (28)

$$x\% = \frac{V_s}{V_s + V} \quad (28)$$

wherein V_s is the volume of free carbon dioxide determined in step f.) and V is the volume of aqueous medium, in which no free carbon dioxide bubble is present, as defined in step g.);

i.) comparing the calculated carbon dioxide concentration to the target carbon dioxide concentration; and,

j.) if the calculated carbon dioxide concentration is greater or less than the target carbon dioxide concentration, lowering or raising the volume of carbon dioxide supplied.

25. A dual core-module apparatus comprising: an apparatus having piping for processing 2- or 3-phase fluids at a dynamic state, said apparatus including two core-modules each comprising a density and temperature gauge having a pressure gauge located upstream thereof and a pressure gauge located downstream thereof, said two core-modules being operatively joined together by a pressure changing device.

26. A single core-module apparatus comprising: an apparatus having piping for processing 2- or 3-phase fluids at either a dynamic or static state, said apparatus including a density and temperature gauge having a pressure gauge located upstream thereof and a pressure gauge located downstream thereof, said apparatus further including a pressure changing device being either a fluid control valve located either upstream of the pressure gauges or downstream of the pressure gauges or both or an optional pump.

27. A static density measurement apparatus comprising: a process fluid reservoir and a pump operatively joined to piping through which a 2- or 3-phase fluid may be pumped, said apparatus including a density and

temperature gauge having a pressure gauge located upstream or downstream thereof, said apparatus also including three fluid control valves located respectively downstream of the pressure gauge, upstream of the density gauge, and in a section of the piping that does not interconnect with either of said gauges, said apparatus further including a pressure regulator located upstream of all three fluid control valves.

28.   A static volume measurement apparatus comprising: a piston cylinder type of device having a sample measurement chamber with a precisely controllable/determinable volume for process 2- or 3-phase fluids, said device including a pressure and temperature gauge, said device also including a sensor for determining the volume of the said sample measurement chamber in terms of the cylinder displacement, said device further including inlet and outlet valves for handling said fluid in and out, respectively.

29.   A measurement procedure of obtaining data, on a continuous basis, for use in determining amounts of gas entrained or dissolved in a 2- or 3-phase fluid, which procedure comprises the steps of:

providing an apparatus according to claim 25;

processing the said fluid at a flow rate such that the pressure level differs between each of the dual core-modules by at least 1 psi or at least to the extent that two different apparent densities of said fluid differ from one another by at least 0.2%;

collecting temperature, pressure and apparent density data from the first core-module while operating at steady-state conditions;

collecting, SIMULTANEOUSLY, temperature, pressure and apparent density data from the second core-module while operating at steady-state conditions; and

calculating entrained/dissolved gas using the algorithms (22)-(24) and (28).

30.   A measurement procedure of obtaining data, at a dynamic state, for use in determining amounts of air entrained or dissolved in a 2- or 3-phase fluid, which procedure comprises the steps of:

providing an apparatus according to claim 26;

processing the said fluid through the core-module;

collecting temperature, pressure and apparent density data at a first pressure level while operating at steady-state conditions;

changing the pressure so that the pressure levels differ from one another by at least 1 psi or at least to the extent that two different apparent densities of said fluid differ from one another by at least 0.2% by either adjusting downstream/upstream pressure or increasing/reducing the flow rate;

collecting temperature, pressure and apparent density data at a second pressure level while operating at steady-state conditions; and

calculating entrained/dissolved gas using the algorithms (22)-(24) and (28).

31.   A measurement procedure of obtaining data at a static state for use in determining amounts of air entrained or dissolved in a 2- or 3-phase fluid, which procedure comprises the steps of:

providing an apparatus according to either one of claim 25 or claim 26 or claim 27;

subjecting/pressurizing the said fluid into the apparatus at a no-flow state;

collecting temperature, pressure and apparent density data at a first pressure level when there is no longer any significant change in data;

increasing or reducing the system pressure to levels that differ from one another by at least 1 psi or at least to the extent that two different apparent densities of said fluid differ from one another by at least 0.2%;

collecting temperature, pressure and apparent density data at a second pressure level when there is no longer any significant change in data; and

calculating entrained/dissolved gas using the algorithms (31), (32), (24), and (28).

32.   A measurement procedure of obtaining data at a static state for use in determining amounts of air entrained or dissolved in a 2- or 3-phase fluid, which procedure comprises the steps of:

providing an apparatus according to claim 28;

diverting the said fluid into the sample measurement chamber;

closing the sample chamber and pressurizing it to a first pressure level which could be below or above the atmospheric pressure depending on the degree of gas dissolved in the said fluid;

collecting temperature, pressure and the volume of the sample chamber in terms of displacement at the first pressure level when there is no longer any significant change in data;

compressing or expanding the volume of the sample chamber by increasing or reducing the pressure level so that the pressures differ from one another by at least 1 psi or at least to the extent that two different volumes of the said sample chamber differ from one another by at least 0.2%;

collecting temperature, pressure and the volume of the sample chamber in terms of displacement at a second pressure level when there is no longer any significant change in data; and

calculating entrained/dissolved gas using the algorithms (35), (36), (24), and (28).